MODIS SEMI-ANNUAL REPORT
- July 15, 2000 -

UNIVERSITY OF MIAMI
RSMAS/MPO

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CONTENTS

A. PERSONNEL

Personnel supported for the first half of 2000 include:

B. Evans (Jan, Feb, Mar, Apr, May, Jun)

V. Halliwell (Jan, Feb, Mar, Apr, May, Jun)

K. Kilpatrick (Jan, Feb, Mar, Apr, May, Jun)
J. Jacob (Apr, May, Jun)
A. Kumar (Jan, Feb, Mar, Apr, May, Jun)
J. Splain (Jan, Feb, Mar, Apr, May, Jun)
S. Walsh (Jan, Feb, Mar, Apr, May, Jun)
R. Kolaczynski (Jan, Feb, Mar, Apr, May, Jun)
D. Wilson-Diaz (Jan, Feb, Mar, Apr, May, Jun)
J. Brown (Jan, Feb, Mar, Apr, May, Jun)
E. Kearns (Mar, Apr, May, Jun)
A. Li (Jan, Feb, Mar, Apr, May, Jun)

B. OVERVIEW OF RECENT PROGRESS

B.1 Processing and Algorithm Development

A-side sensor characterization:

Before the MODIS ocean data can be fully utilized by the scientific community, the performance of both the complex sensor system and the algorithms must be evaluated. The sensor characterization examines several issues, including detector-to-detector discrepancies within wavebands, variations in the mirror response as a function of angle of incidence, differences in characteristics between mirror sides, effects of spatial and spectral cross-talk, and problems associated with polarization and sun glint.

Early at-launch images (Fig.1) demonstrated severe striping and discontinuities in both the along and cross scan direction.

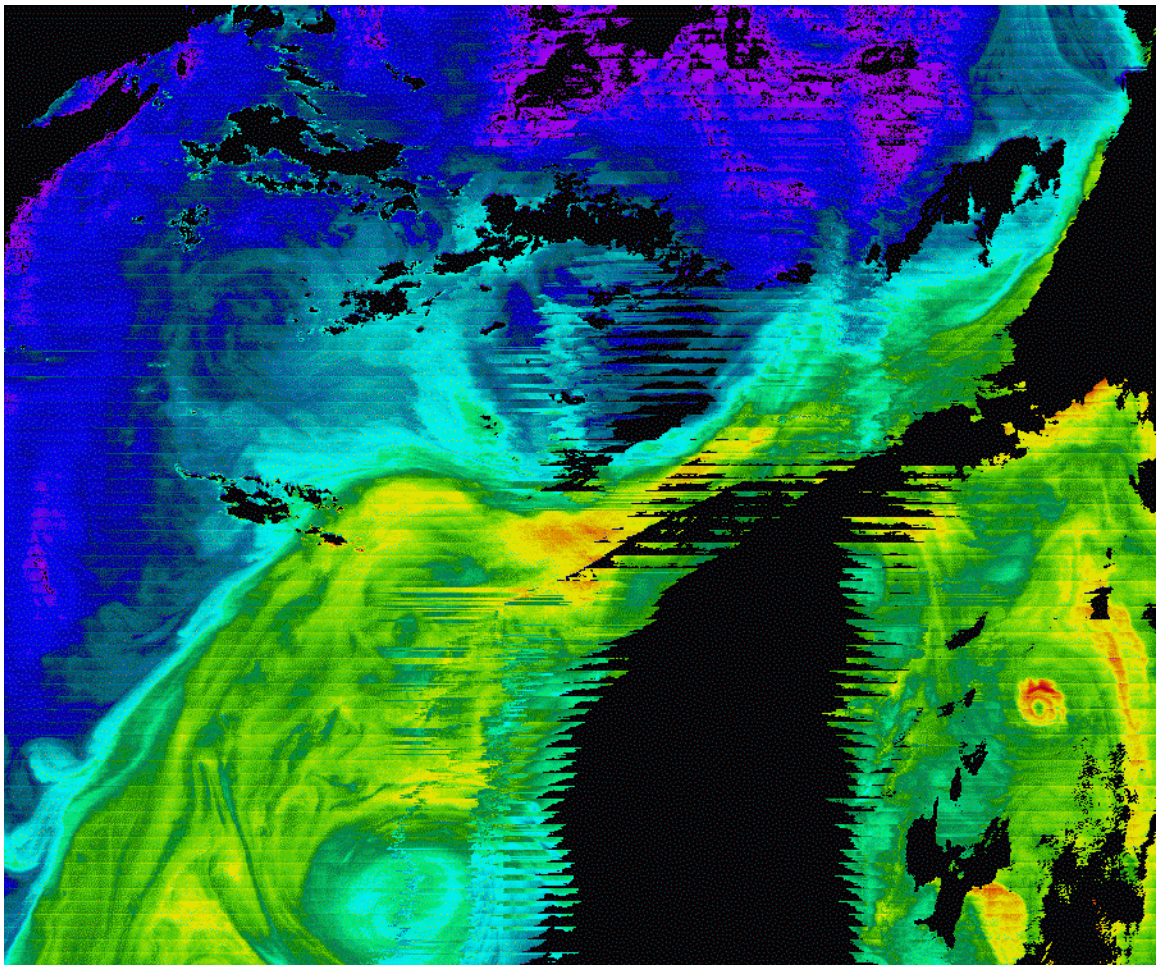


Figure 1. Uncorrected image Level 2 1-km nLw_443 unmodified.
East Coast U.S.
May 8th, 2000 (L1b v2.4.3, 129:1545).
Note non-physical structure extending from black sun glint region

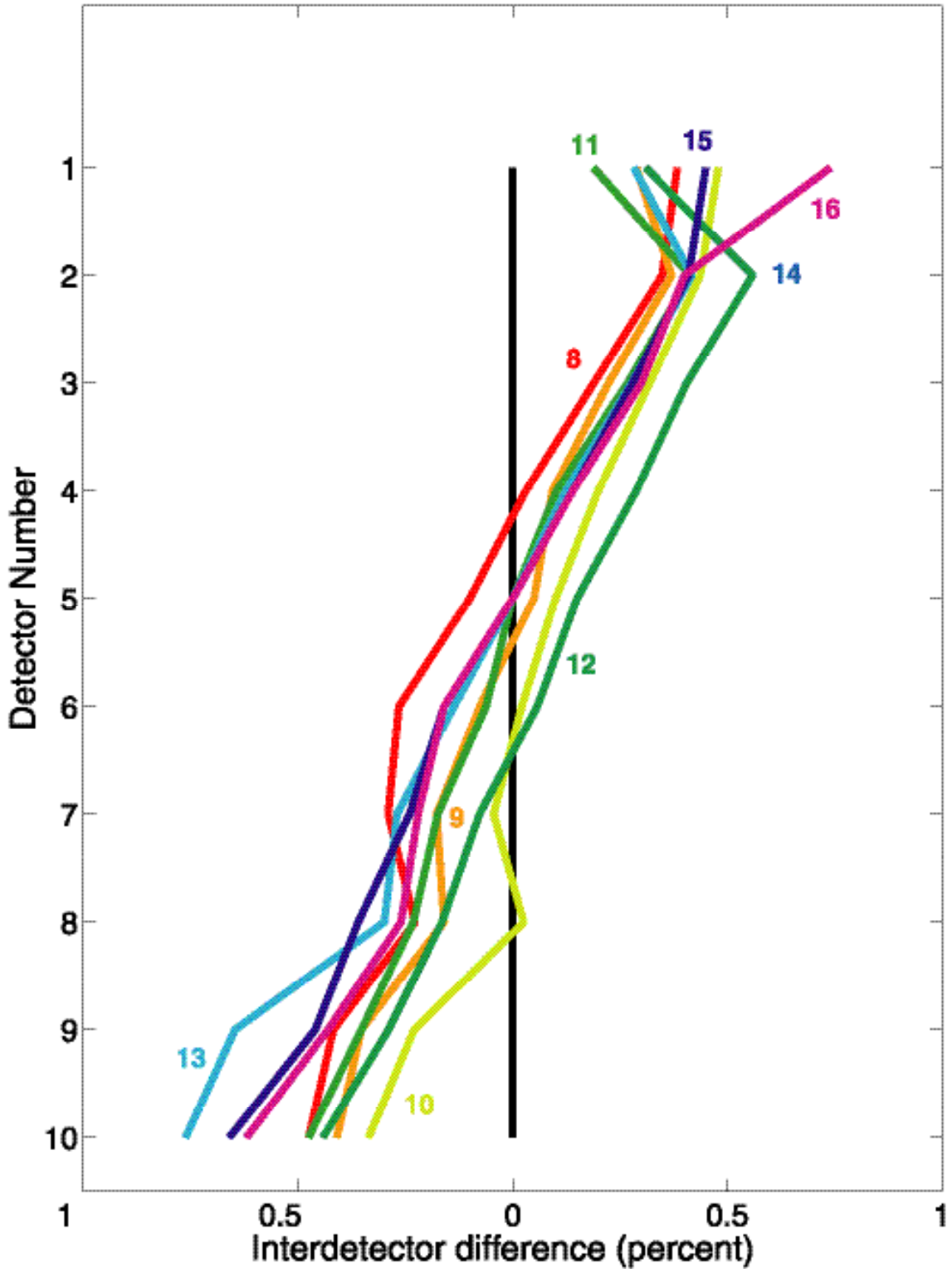
The large portion of the gross striping pattern seen in Figure 1 is the result of an unbalanced response between the 10 detectors within a scan line. Multiple detectors must be balanced at the level of the precision of the detectors (i.e. 12 bit system). Detectors must therefore be balanced to better than 0.1% or severe striping will be present.

Work has begun on the adjustment of the inter-detector differences and is expected to continue into the 2nd half of 2000.

-Inter-Detector gain adjustments

Figure 2 shows a plot of the at-launch relative response of each of the 10 detectors. A general increasing linear response from detector 1 to detector 10 on the order of ~1% is present in all bands. The black line represents the inter-detector response after gains were adjusted by normalizing response to detector 5 and filtering La.

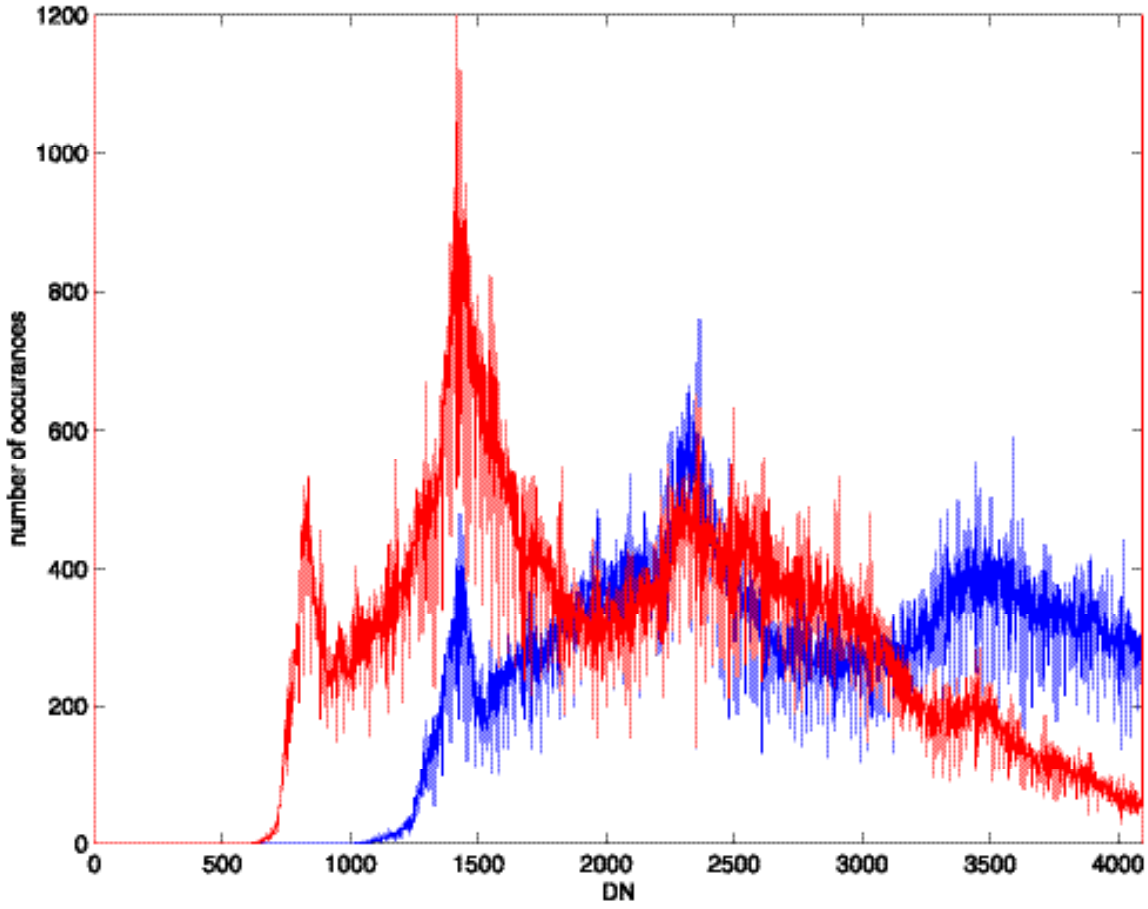
Figure 2. Percent inter-detector modal differences for each visible band.



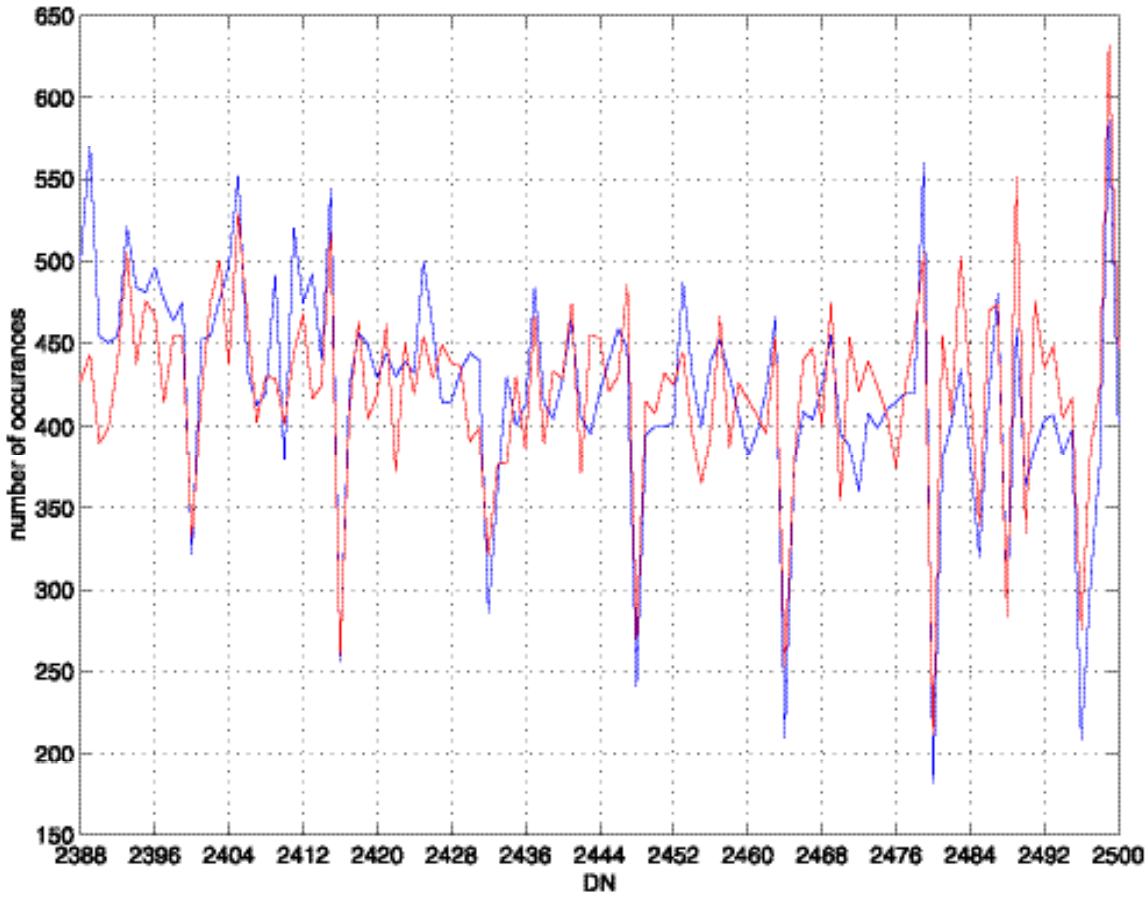
Digitizer noise

Examination of digitizer counts demonstrates noise in the sensor A/D conversion Figure 3. The expanded scale shown in figure 5 clearly shows 2n –1 -> 2n transitions. This digitizer noise causes the La fields to be quite noisy and is problematic for the atmospheric correction.

Figure 3. Histogram of digitizer counts.



A. full range of digitizer counts



B. expanded view of 2000-2500 count range

Outstanding issues

Mirror side ambiguity: Offsets are required to compensate for different reflectivity of the two scan mirror sides; at times mirror side identity is uncertain leading to scan striping. Principally affects 412nm, 443nm, and IR bands. This “mirror sidedness” is also apparently a function of time, an d it’s effects may be solar zenith depen

t sun glint scale factor (glintsc): Using a glintsc factor of 2.0 produced consistent behavior in Lw's fields, however, examination of global images showed asymmetric chlorophyll behavior from west to east along the scan line. Decreasing the glintsc factor to 1.4 produced consistent Chlorophyll behavior at the expense of the Lw retrievals. A glintsc factor of 1.65 was found to be an acceptable compromise to produce "reasonable" behavior in

both Lw and chlorophyll fields. This glint correction is only approximate and needs further development.

Asymmetry in epsilon and Lw fields: Global fields show a persistent asymmetry from west to east. From the sun glint progressing to the eastern side of the image, epsilon and Lw's are uniform in regions of low geophysical variability. Immediately to the west of the sun glint and on the far western side of the image, epsilon and the Lw's tend to be lower; a parabolic shape in both epsilon and Lw retrievals is present as scan angle increases from the west toward the sun glint.

Quality Status Plan of Beta and Provisional and Scientific products

Operational Beta products: March 25th, 2000 – May 30th, 2001
Operational Level 3 Provisional products – expected June 1,2001 – November 30th 2001
Operational Scientific products – expected December 15, 2001

Beta products:
Beta products are derived from at-launch preliminary algorithms and are used for evaluation purposes only, and should not be used by the general community for rigorous scientific analyses. These beta products are not certified with respect to accuracy and/or uncertainty. We estimate that Beta products will be produced operationally though May 2001. The Ocean's team plans to release a quantified Quality Status summary report and error budget for A-side Beta products in mid- April

Known problems identified in Beta products to date include;

- Not calibrated

A preliminary calibration was performed using April 2000 in situ data. This calibration became operational for data-days September 15, 2000 (259) through October 30, 2000 (304). However, while this April calibration performed reasonably well on April test data it has proven unsatisfactory when applied operationally. Following the April 2001code revision, we have the ability to easily swap Ocean calibration LUTs, allowing more rapid promotion of revised time dependent calibration tables to operations. Some improvements in the accuracy of operational Beta products should occur as calibration is adjusted in a time dependent fashion.

- Other Artifacts currently identified

Response versus scan angle (RVS)
A noticeable east-west difference across the scan line is present and is more pronounced at low latitude. This east-west difference includes a spectral component and is most evident in the Lw412nm and Lw443nm bands. The impact on specific products is highly dependent on choice of spectral bands.

The viewing geometry for MODIS is very different than previous ocean color sensors; we believe that a portion of the RVS artifact may be traceable to a bi-directional reflectance (BRDF) effect not currently included in any of the beta atmospheric correction algorithms. The work of Ken Voss suggests that maximum variation across the scan due to BRDF is expected to be on the order of 10-15%, and thus, does not fully explain the magnitude of the RVS artifact present in the MODIS data. Continued analysis is needed to fully understand the RVS issue.

Mirror side differences
Gains are not completely balanced between the two mirror sides resulting in striping. The mirror side differences become more pronounced at higher scan angles (>55 degrees satellite zenith angle; +/-75 pixels on each end of the scan line). These pixels are currently being masked in the level-3 operational products as of data date October 10,2000.

Angle of incidence (AOI)
Detector response appears to change as a function of mirror AOI, increasing stripes.

Digitizer noise in IR bands
A-side electronics introduce noise in the sensor A/D conversions, affects 2(n-1) -> 2n transitions. Additional filtering to remove this noise will be required. B-side electronics have been found to reduce digitizer noise and revised detector bias settings produce fewer dead detectors.

Channel cross-talk; electrical and optical have been identified in the L1b product

Inter-detector discrepancies

The gains on the 10 detectors in a scan are not completely finalized. The imbalance between detectors results in striping and is accentuated by differences in mirror side and at high scan angles. Uncorrected inter-detector discrepancies were severe on the A-side electronics following instrument problems that occurred on June 22, 2000 (day 174) and were found much improved on the B-side, although the problem still remains on a lower level,

Polarization and sun glint corrections
Current polarization and sun glint corrections are only approximate and will be refined in the future. Insufficient polarization corrections may also be implicated in the magnitude of the RVS problem.

- Impact of known artifacts on level 3 global images

Due to the large number of identified artifacts there are very few high quality pixels at level 2. This violates a fundamental assumption of the current time and space binning rules and algorithms used to create global level 3 products. In a theoretical sense as a product progress to lower time and space resolutions both the accuracy and the quality of the retrievals should increase. This is not seen in the Beta products to date, due to the fact that as the product moves to decreasing resolution the number of level-2 pixels summed per bin increases, and results in large numbers of poor quality pixels biasing the signal of the few with high quality. The current binning algorithm has the ability and does attempt to “filter” out bad level 2 pixels, for a single level-3 bin only candidate level-2 with the highest assigned quality level available are summed, but adjacent bins may not be of equal quality. One solution is to operationally bin only pixels assign the absolute highest quality level (quality level=0) and not the “best” available. This restriction will improve the accuracy of the products but will severely restrict geographic and temporal coverage; many oceans bins will be empty at the 4km time resolution of daily. Currently the user can accomplish this with the Beta products to date, if the user filters the data using the archived bin quality level maps distributed with the product and the cloud mask.

Provisional level 3 products

Provisional Level 3 products are expected in operations by July 1,2000. These products will show a dramatic improvement in the overall accuracy of

the global products; however, currently this can only be accomplished by a dramatic reduction in the global coverage through the use of very restrictive binning rules to mask out problems.

During the next several months the Oceans team will make the following improvements to bring operational products to Provisional status:

A. B-side calibration of Lw's and brightness temperature using Preliminary (#B1) December 2000 cruise data
   Time dependant calibration refinements (#B2…) referencing MOBY buoy, MAERI Explorer cruise data. Calibration refinements will be rapidly promoted into operations as they become available.

B. Improved product specific flags and quality level assignments used by binning algorithms. Ensure that pixels with inaccurate retrievals are not included in the level-3 global products and are assigned to quality level 1 and greater. Explore defining additional quality levels internal to ocean code to better identify potentially useful pixels.

C. Implement highly restrictive binning rules to mask out identified artifacts that are poorly understood and not adequately captured by existing quality and product specific flags.

D. Mitigate the impact of known but poorly understood artifacts in derived products through the use of additional calibration coefficients developed from comparisons to SeaWiFs and AVHRR equivalent products, (i.e. force agreement)

Operational 1km Level-2 products will remain at essentially the Beta level, although improvements will be evident due to improved calibration and detector balancing performed as part of activities outlined in above in A. The majority of known artifacts will likely remain in these products. Only level-3 4km and lower resolution products will be promoted to Provisional status as a result of the above changes.

Quality control and assessment:

-Science QA tools

Parallel processing of selected days and at the Miami SCF
Complete archive of MOD1ss and ancillary data. Data have been processed at Miami for:

- Comparison to MODAPS production
- Analysis of select L1,L2 and L3 granules to understand sensor characterization and calibration
- Comparisons to other sensors e.g.. SeaWiFS and AVHRR Pathfinder SST
- Evaluation of QC products and various pixels level Flags
- Testing of new algorithms

The Miami processing can be viewed on the web site http//miracle.rsmas.miami.edu.

-Tracking of PGE02 LUT's

The Miami SCF has been participating in weekly telcons with MCST in regard to MOD02 calibration tables. The Miami SCF monitors the delivery and installation into operations of all changes to PGE02 LUT's.

-Storage of QA results

Pixel level information (set during processing stored as an SDS in the HDF file)

- Common flags
- Product specifc flags
- Quality levels
- Granule level (QA metadate updates after ingest)
- Science QA flag
- flag explanation
- Currently we still cannot update the QA metadata at the DAAC and rely on the known problems page to communicate this information to

the user

QA Communications to the end users

Provided content and pages for the MODIS OCEAN QA web site these web documents include:

Disclaimer and known problems web site
- General disclaimer and product status
  - Beta, Provisional and Science
  - Listing of known problems under investigation
  - Listing by product of QA_science flag and flag explanation gives dates when QA flags change and period

Oceans web pages http;//modis-oceans.nasa.gov
- general product information and sample IDL codes for reading pixel quality levels, common flags, and product specific flags. Stored in product hdf files
- Trouble ticket web page tracks status of end user reported problems received at the GDAAC

QA database

The QA database is a central component in the process of documenting problems in the MODIS oceans data and updating the associated metadata so that this information can be made available to the scientific community. The database provides a repository for QA data on each level 2 granule and global ocean products. Basic QA data consists of flags (pass, fail, and others) and comments at the parameter level. This information is used by associated software to generate metatdata update messages which will be processed at the GSFC DAAC when this functionality becomes available.

-QA database
The system is loaded with L2 and L3 granule metadata from MODAPS and ECS insert metadata publications (containing the ECS UR of the granule). Potential problems are identified based on the analysis of globally mapped daily composites. An email message is generated by the 36Km browser QAdatabase_tool containing the parameter, geographic location and description of the problem and this information is stored in the database.

Problems are investigated and the database updated with appropriate QA flags and comments. An associated program will use this information to generate e-mail messages to update the ECS QA metadata ScienceQa_flag and flag_explanation for granules archived at the DAAC when bulk updates become possible in the ECS system.

B.2 Matchup Database

B.3 Systems Support

Here are the things that were done to MODIS DSP code in the first half of 2000.

binshr/settbinmeta:

Change Sensor name in metadata to either VNIR or TIR.

binshr/fixuplong:

Use 'int' instead of 'long' for 32-bit values.

modcol:

Change Sensor name in metadata to either VNIR or TIR.

Add VerParm's for the QC products.

Add info to error messages.

Add frame number input argument to ASCDSCSUB.

Pass ScanMode and MirrorSide back from the L1b record read.

Read 13 and 14 high instead of low.

Add checks to make sure navigation is correct.

Add option to output total radiances (RADD) instead of 9 of the QC products.

Add option to output total radiances (RADD) instead of 9 of the QC products.

Include bandnums in common area.

Read in radiance corrections and apply offsets.

Add archived metadata string to metadata routine for bounding coordinates.

Change mirrorside from 0-1 to 1-2.

Change mirrorside to integer 1 or 2; change radiance correction arrays; add correction equations (APPLY_RAD_FACTOR).

Add separate Rayleigh wind speed routines.

Add docorr input variable.

Add slope adjustment to radiance corrections.

ifdef out debugs.

Add daily solar variation to input radiance scaling.

Add usepol variable.

Extrapolate for AOI off edges of tables (scan angles > 45 degrees).

Correct wind/wavelength indexing to match binary table generation.

Change from 9 to 11 input channels (13l/13h and 14l/14h).

Add polarization correction.

Change from 9 to 11 input channels (13l/13h and 14l/14h).

Declare list of input bands and number of input bands in only one place.

Add processing control attribute to output files.

Changes for 11 input bands.

Remove duplicate declaration of two variables.

Remove call to REFinit, not used.

Correct call to REFread, only four arguments.

Remove call to REFinit, not used.

Make variable long enough for string.

Use definition from colorin1.h.

Correct field name.

9 to 11 input channel changes.

scantime is two element vector.

3x3 average for inputs 10 and 11 (bands 15 and 16).

Wrap wind speed printout with debug conditional.

Correct diagnostic flag usage for 11 input channels.

Clean up float/real usage.

Input value of 0.

is not valid (quadratic root returns 0).

Add divide by zero check.

Add diagnostic flag for sun below horizon.

modsst:

Change Sensor name in metadata to either VNIR or TIR.

Add frame number input argument to ASCDSCSUB.

Pass ScanMode and MirrorSide back from l1 record read.

Apply radiance offsets.

Return ScanMode and MirrorSide from L1 record read.

Change QC RAW's to radiances.

Change chan 22 detector 8 offset.

Average detecters 3 and 5 to replace 4 for chan 22.

Put chan 22 detector 8 offset back to the original 0.00181.

Check for geolocation problems to fix ascend/descend calculation.

Replace chan 22 detector 8 with average of detectos 7 and 9.

Replace bright22 with sst4 with channels 20 and 23.

Fix new sst4(20,23) in bright22 slot.

Read radiance corrections from a coeff file.

Fix some comments and error messages.

Fix REPROCESSINGACTUAL metadata field, array was too short.

Use correct counter variable for channel 22 2nd non-uniformity test.

Use getcorrections from atmcorshr, share it with modcol.

Make single detector fixes optional with DOCORR keyword (a temporary solution).

Set quality to worst if L1b inputs are bad.

Add outtlwd keyword to optionally replace bright22 with 20/23 sst4.

Mark the last 4 pixels of the scan line for chan32 as bad.

Add archived metadata string to metadata routine for bounding coordinates.

Change mirrorside to integer 1 or 2; change radiance correction arrays.

Get 'docorr' and 'usereals' from modsst_params coeff file.

Add 'usereals' option to output either reals or 16 bit integers.

Add 'slopeadj' coeffs from getcorrections, to be consistent with modcol.

Output 'Processing Control' output to both files to show command line inputs (pcf and coeff inputs).

Add 'docorr' to optionally apply radiance offset and detector replacement.

Add 'docorr', 'lats', and 'usereals' to command line echo in 'Processing Control' attribute.

Read OUTTLWD from the param file, and echo it in the Processing Control attribute.

Change RadRange to real.

Fix and modify radiance corrections.

Fix usage of CHAN26.

Comment out mirror side corrections, and always average chan22 detector 4.

Another IR correction: pixel offsets for mirror side 1.

Echo inputs biasr and sloper.

Read biasr and sloper from input param file.

Change defaults for temp biases to Kelvin.

Fix handling of biases (K vs C).

Fix handling of real vs scaled integer output values.

ifdef out some debugs.

Use ave instead of cen for sst calculation.

msbin:

Change Sensor name in metadata to either VNIR or TIR.

Allow dataday info to be passed in instead of calculated.

Fix time string.

Pcf file should specify asc/dsc beg/end and dataday to avoid calculation.

All or none of the data day bounds must be specified.

Hard code the data day start/end time.

If dataday info is not specified then try calculating them using the toolkit, if that fails then use constant time and calculate dataday days.

Remove old code.

Ignore 'predicted utcpole data' warning.

Add archived metadata string to metadata routine for bounding coordinates.

Add support for integer or real L2 values.

Comment out unused variables.

Only read Data Sensor Type attribute if input is MOD28 (sst type).

Fix typo.

Add check for 'no leap seconds' warning.

Fix wrong index causing memory overwrites.

Change some variable names to make it easier to search for specific index variables.

modisio/v2_meta:

Change Sensor name in metadata to either VNIR or TIR.

For L2 files, copy bounding coordinates from MOD02.

Fix portability problem with field step size.

mspc:

PGS_SMF_SetDynamicMsg was declared twice.

Check for fill values in bin numbers.

mfill:

Move code to echo input parameters to be before one is modified.

Add debugs.

Use WATBINS for output size.

mtbin:

Check for fill values in bin numbers.

Add option to keep warmest pixel instead of sum.

Fix warmest pixel option.

mcolshr8:

Add significant digits to constant (PI).

Change airmass calculation to work around 90 degree zenith angle.

Remove/comment out unused variables.

msstshr5:

Disable definitions not in use.

Correct trailing digits of constant (PI).

Increase zenith angle test value for day/night.

Correct satellite azimuth angle for sensor orientation.

Adjust azimuth angle calculations to lie in canonical range.

Change airmass calculation to work around 90 degree zenith angle.

ml3b2mia:

Add comment for consistency with other programs.

Write start and end time of data to associated data block.

Use proper platform names.

Add option to output 16 bit integers.

Add start date and time to navigation block and subimage header.

Fix function type.

mmap:

Change number and contents of mmap_params coeff files.

Fix attributes in output file.

Get band name from 'sum' SDS.

Optionally scale output to 8 or 16 bits.

Put product name in scaling equation.

Add input option to specify output file pixel size (8 or 16 bits), keyword PIXSIZ.

Fix handling of byte flags.

inc/ocean_lun:

Add new LUN for new mmap coeff file.

Add LUN for polarization correction coefficient file.

atmcorshr:

Add routine to compute airmass for zenith angles near 90 degrees.

Modify ASCDSCSUB to only check one line of each frame for pass direction (as consecutive frames overlap).

Add frame number input argument.

Add getcorrections; used by modcol and modsst to get radiance corrections.

Change radiance correction arrays.

Add slope adjustment factors.

RadRange is real.

Fix limit value.

Add declaration for modcol.

Rearrange code to eliminate divide by zero.

Simplify logic.

Add comments.

ml22mia:

Fix flag bytes.

Change some scaling values.

Add option for total radiances in oc qc products.

Put start date and time in subimage header.

Change some slopes.

modisio:

Return ScanMode and MirrorSide in L1 record read.

Change mirrorside to integer 1 or 2.

mwhere:

Make swath width a variable.

Add day/night calculation and output value.

Use bearing/range subroutine from orbitshr library.

Clean up source formatting.

mremapn:

Remap MODIS L2 data into dsp files.

Fix to work on dec and sgi.

Use modis library instead of a copy.

Fix calibration mix up.

invgeo:

MODIS inverse geolocation routine.

Fix makefile so mapi include directory is only listed once.

l3m2mia:

Must use IMGFILE to declare image header variables.

Comment out unused include file.

reformat-mod:

Modify for updated Rayleigh table formats.

readpol-mod:

Remove unused code.

inc/commoninout:

11 input bands for modcol.

mocean:

Implement GetBandPixelType.

io:

Add caleval module.

B.4 Team Interactions

Bruce Guenther, Jack Xiong, and Wayne Esaias visited RSMAS during the first half of 2000 to discuss our findings regarding the MODIS instrument. The problems with the instrument (detector striping, mirror

sidedness, digitizer errors, out-of-family or dead detectors) were discussed and possible solutions discussed. Bob Evans attended the MODIS team meeting. Continuing discussions are held between the RSMAS and Ocean Processing QA teams. Sue and Kay hold discussions with the ocean PI's to coordinate algorithm updates.

C. Future Activities

C.1 Processing and Algorithm Development

During the next several months the Oceans team will make the following improvements to bring operational products to Provisional status:

- B-side calibration of Lw's and brightness temperature using Preliminary (#B1) December 2000 cruise data. Time dependant calibration refinements (#B2) referencing MOBY buoy, MAERI Explorer cruise data. Calibration refinements will be rapidly promoted into operations as they become available.

- Improved product specific flags and quality level assignments used by binning algorithms. Ensure that pixels with inaccurate retrievals are not included in the level-3 global products and are assigned to quality level 1 and greater. Explore defining additional quality levels internal to ocean code to better identify potentially useful pixels.

- Implement highly restrictive binning rules to mask out identified artifacts that are poorly understood and not adequately captured by existing quality and product specific flags.

- Mitigate the impact of known but poorly understood artifacts in derived products through the use of additional calibration coefficients developed from comparisons to SeaWiFs and AVHRR equivalent products, (i.e. force agreement)

C.2 Matchup Database

Collection of coincident MOBY/MOS data and MODIS ocean color granules will continue. Pathfinder SSTs will be processed at 4km global resolution to aid in comparison to MODIS SST and SST4. In situ buoy/drifter and MAERI SSTs will be collected, and routines to extract corresponding MODIS pixels will be developed.

C.3 Systems Support

Many modifications to the MODIS code are expected.

C.4 Team Interactions

Upcoming presentations:

1. Oceans from space -Venice
2. Ocean optics – Monaco
3. PORSEC – India
4. QAWG – Boulder